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THE EFFECT OF TEMPORAL INTERVALS OF REINFORCEMENT UPON DEDUCTIVE AND INDUCTIVE GENERALIZATIONS.

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Using verbal material, this study explored the effect of the temporal interval of feedback as it interacted with two other variables: (1) method of presenting learning material (inductive or deductive), and (2) activity of the learner during the delay interval (activity relevant or irrelevant to the material). The major objective was to compare the effect of immediate versus delayed feedback of knowledge upon the learning of principles, using principles typical of the content of lower division college instruction. The subjects were 277 lower division college students selected from a large introductory psychology class. The universal superiority of immediate reinforcement did not appear. The educational implications are: (1) the usual assumption of the efficiency of immediate reinforcement is not valid with respect to academic instruction; and (2) the apparent superiority of delayed knowledge reinforcement with deductive learning and immediate knowledge reinforcement with inductive learning may be utilized across a wide range of instructional settings. (Author)

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THE EFFECT OF TEMPORAL INTERVALS OF REINFORCEMENT UPON
DEDUCTIVE AND INDUCTIVE GENERALIZATIONS

Cooperative Research Project No. S-271

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THE PROBLEM

The study focused upon the relative efficacy of delayed vs immediate feedback of knowledge, i.e., information about the correctness of response. Despite widespread belief in the superiority of immediate feedback, supporting evidence based upon the use of typical academic verbal material is extremely scant. Using verbal material, this study explored the effect of the temporal interval of feedback as it interacted with two other variables:

1. Method of presenting learning material: inductive or deductive.
2. Activity of the learner during the delay interval: activity relevant to the material or irrelevant activity.

Inasmuch as the learner's receiving immediate feedback were allowed no delay interval, the activity of such groups was varied after the feedback.

OBJECTIVES

The major objective was to compare the effect of immediate vs delayed feedback of knowledge upon the learning of principles, using principles typical of the content of lower division college instruction. Secondary objectives were to explore the interaction of the major variable, indicated above, with two additional variables:

1. The method of learning a principle: deductive vs inductive.
2. The presence of non-informative material supporting relevant symbolic activity vs the absence of such material.

HYPOTHESES

1. Delayed feedback will result in superior verbal learning.
2. The presence of non-informative symbolic supporting will result in superior verbal learning as compared to the absence of such material.
3. The interaction between temporal interval of feedback and supporting material will be significant. Such significance will result from the positive learning increment due to both delayed feedback and induced symbolic activity.
4. The hypotheses indicated above (1, 2, and 3) will be supported by both inductive and deductive methods of presentation.

RELATED RESEARCH

The view that learning varies inversely with the amount of time intervening between a response and reinforcement is incorporated in several prominent theoretical approaches to learning (Hull, 1952; Spence, 1956; Miller, 1950; Skinner, 1938, 1957). Furthermore, this notion of the superiority of immediate reinforcement has been included in almost all attempts to apply principles of learning to education practices. Current textbooks in educational psychology often cite this as a fundamental principle of learning. Klausmeier (1960) states

Reinforcement immediately following the correct response usually facilitates learning more than does a delayed reward or reinforcement. The teacher must know what the correct responses are and observe and reinforce them immediately. The greatest possibility for the improvement of all human abilities seems to lie at this point...

Blair, Jones, and Simpson (1962) suggest, "From what is presently known, feedback is more effective if immediate and specific." Bigge and Hunt (1962) state, "The key to effective teaching of thinking, as any other behavior, is immediate feedback." Similar claims for the superiority of immediate reinforcement in classroom learning can be found in almost any modern textbook of educational psychology.

The booming expansion of teaching machines has further emphasized this principle. All current programs for teaching machines appear to be based on the notion that immediate reinforcement is the most effective condition for learning. Holland (1960), co-worker of Skinner and a key figure in the development of teaching machine programs, suggests that of several well-known learning principles to be applied to teaching machine development, "immediate reinforcement for correct answer is a must..." Similar authoritative assertions, proclaiming the necessity of immediate reinforcement, are found throughout the literature pertaining to teaching machines and programming. In teaching machine programs in programmed tests as well, the reinforcement consists of either informing the student of the correct answer or telling him whether his answer was right or wrong.

Although this new medium focuses attention upon the importance of immediate reinforcement, its application is not limited to programmed learning. Broadly conceived, reinforcement is any consequence following a response which results in increased likelihood of that response in the future. Thus, telling a student that his answer is right or wrong, handing back tests, assigning grades, the teacher's approval of any student behavior are all examples of reinforcement. Much of the teacher's behavior may be considered as the application of reinforcement. Consequently, valid principles of reinforcement have broad applicability to educational practice. Therefore, it is crucial that any asserted principles be validated upon relevant human learning problems. If the principle of the superiority of immediate reinforcement is tenuously founded or even erroneous when applied to typical classroom learning, educational progress may be seriously retarded.

Empirical evidence for the principle of immediate reinforcement has been derived from three types of studies:

- A. animal experiments
- B. studies of human motor skills
- C. experiments using typical classroom material

Numerous animal studies supporting the immediate principle can be found in any experimental learning text. Samples might include: Wood (1933), Perin (1943), Grice (1948), Carolton (1954 and Myles (1958). However, a slender, but persistent, current of conflicting evidence appears even among animal learning experiments.

Such early studies as Warden and Haas (1927) indicating no inefficiency from delay were later explained by positioning a secondary reinforcing effect derived from cues, e.g., the goal box, previously associated with the reinforcing food. The power of derived or secondary reinforcers to bridge the delay gap has been heavily relied upon by major learning theorists: Hull, Spence, Mourer, and Skinner. Such reasoning would imply that highly distinctive cues during the delay interval might remove any deteriorious effect. Results consonant with this were found by Renner (1963).

The function of the delay interval as a source or catalyst of motivation is suggested theoretically by both Mourer (1960) and Spence (1957). Empirical support for such an effect is found in studies by Raymond (1954) and Bebeler et al (1957). In these studies speed of locomotion was the dependent measure. The rodent subjects displayed faster running under delayed conditions.

The effect of delay upon animal performance needs to be examined in light of the subject's previous experience with temporal dimensions. Studies in which training trials utilized increasing or variable delays Dews (1960), Logan (1960) support that both accuracy of discrimination and speed of response can be facilitated by controlled use of delayed feedback.

Subject to the above considerations, rat experiments generally show that speed and latency of response are adversely affected by delay of reinforcement. However, if other measures of learning are used, the effect of delay is by no means clear-cut. Evidence of learning interference from delay was found by Perin (1943b), Grice (1948) and Lawrence and Hommel (1961). However no effect of temporal delay upon the number of trials to acquisition was found by Renner (1965), Roberts (1930) and Wolfe (1934).

Evidence from human motor skill tasks casts further doubt on the superiority of immediate reinforcement. Several studies (Lorge and Thorndike, 1935; Saltzman, Kanfer, and Greenspoon, 1955; Noble and Alcock, 1958; Denny, et al, 1960) found no difference between immediate and delayed feedback upon the acquisition of such responses as drawing lines of a specified length, moving a bar, pulling a lever, etc. Bilodeau and Bilodeau (1958) in a series of five studies found no interference on motor skill from delay, and in one case delay resulted in improved learning. In their review of the effect of delay of reinforcement upon motor skills learning Bilodeau and Bilodeau (1961) conclude, "Immediate knowledge of results is immaterial to learning so long as the time intervals are free from specially interpolated responses."

Until recently, few experiments had investigated the effect of immediate vs delayed reinforcement using typical classroom material. The earlier studies (Angell, 1949; Little, 1934; and Pressey, 1950) indicated superior learning under conditions of immediate reinforcement. However, in each study the method of administering reinforcement differed between immediate and delayed groups. Thus, in Angell's oft-cited comparison of freshman chemistry students, the immediate reinforcement group used a punch board device to receive feedback while the delayed reinforcement group used conventional answer sheets. No resulting differences can be clearly attributed to temporal differences in

feedback. Differences in mode of administration, novelty effects, and various interactions present possible sources of variance.

Renner's (1964) review of literature on delay of reinforcement does not cite a single study in which verbal stimuli were used. Since the review, several studies employing verbal material have raised doubt as to the superiority of immediate feedback. Jones and Bourne (1964) report several studies exploring the effect of a short unfilled delay interval. No difference was found in performance on a verbal maze using 0-sec. vs 6-sec. delay. On a paired associate task performance improved with increases in both the delay interval (0, 3, and 6 sec.) and in the post-delay interval. Such effects were additive.

A series of studies by Brackbill and associates (Brackbill, Branos, and Stair, 1962; Brackbill, Isaacs, and Snelkinson, 1962; Brackbill and Kappy, 1962; Brackbill, Bohlitt, Darlin, and Wagner, 1963; Brackbill, 1964; and Brackbill, Wagner and Welson, 1964) question the validity of the principle that delayed reinforcement has a detrimental effect on human learning. Further studies (Bilodeau and Bilodeau, 1958; Boulter, 1964; Brackbill and Kappy, 1962; Ryan and Bilodeau, 1962; Crawford and Sturgis, 1964) on human motor and verbal learning problems show no difference in learning due to the time of reinforcement.

The majority of the investigations on delayed reinforcement measure acquisition as evidence of learning. The number of errors or the number of trials required to attain a prescribed criterion is the measure. However, Brackbill, Wagner and Wilson (1964) stress the fact that for practical purposes, it would be more useful to investigate the effect of delayed reinforcement on retention. The authors (1964) feel that more emphasis should be placed on retention instead of on the sole process of acquisition.

Brackbill, Wagner and Wilson (1964) required third grade children to learn eighteen English words and their French equivalents, recording the number of errors and trials to reach a criterion. The difference between the immediate and ten-second delayed knowledge of results (KR) treatments were insignificant. However, when the same measures were taken again seven days later to determine how well the subjects were able to relearn the materials, the delayed KR group did significantly better. Retention, the number of errors in relearning or the number of trials to relearn, has been measured by this study and by Brackbill, Bravos and Starr, 1962; Brackbill and Kappy, 1962; Brackbill, Isaacs and Smelkinson, 1962; Brackbill, Wagner and Wilson, 1964; Lavery and Suddon, 1962; and the results indicate that delayed KR improves retention while immediate KR impairs retention.

However, it is difficult to assess whether the difference in retention is due to the delayed KR or to the fact that during acquisition, the subjects may have been exposed to the materials to be learned an unequal magnitude of time. The subjects receiving delayed KR in the study by Brackbill, Bravos and Starr (1962) and Brackbill and Kappy (1962) required more trials to acquire the material to be learned and consequently were presented with the material to be learned a greater magnitude of time than were the subjects who learned more rapidly. After the material has been presented equally to all subjects, a measure of acquisition may be taken, however, it is difficult to conceive a measure of learning as reflecting only acquisition or only retention, since these two constructs are always confounded in any actual behavior.

Although the majority of the studies, typically using rodent Ss, reviewed by Renner (1964) indicate that learning efficiency decreases with increase in feedback delay; however, when an attempt is made to control for any mediating variables during the delay interval, the results are not as conclusive. Grice

(1948), Perkins (1947) and Harker (1956) demonstrate the ineffectiveness of delayed reinforcement due to the mediating of secondary reinforcing agents and Renner (1968) concludes from his study, "...that the temporal gradient of reinforcement is a function of drive level and availability of cues." Carlton (Spence, 1960) devised a confinement segment in his apparatus which, "...would discourage turning away from the food-cup during the delay period and thus increase the likelihood of maintaining orientation toward it." This increased control of the rat's activity during the delay interval was shown to be a variable which significantly facilitated learning over the rats which were not confined.

The bulk of the studies (Alexander, 1951; Bilodeau and Bilodeau, 1958; Bourne and Bunderson, 1963; Brackbill, Isaacs and Smelkinson, 1962; Brackbill and Kappy, 1962; Brackbill, Wagner and Wilson, 1964; Greenspoon and Foreman, 1956; Landsman and Turkewitz, 1962; Noble and Alcock, 1958; Ryan and Bilodeau, 1962; Saltzman, 1951; Saltzman, Kanfer and Greenspoon, 1955) on delayed reinforcement appear to overlook the time interval between response and reinforcement for any possible effective variable other than the mere passage of time. The studies do not attempt to control for the subjects' activities or stimuli which may possibly be interfering with or facilitating learning. The assumptive framework of such studies appears to regard this time as a temporal vacuum in which "nothing" impinges upon the subject. Obviously, such a state is not experimentally producible at the present and the variables that do occur during this interval of time must be controlled.

The importance of the delay interval for variables other than solely the passage of time was also indicated in Jones and Bournes (1964). Results showed that delay was detrimental only as a function of successive items presented prior to KR. Ross, Hitherington and Wray (1965) demonstrated a poorer

performance of children in a size discrimination problem due to the continual presence of the stimulus during the delay interval. The authors (1965) attributed the effect to competing responses made during the delay interval. Hockman and Lipsitt (1961) "...supposed that effects of delayed reward are dependent upon the effective distinctiveness of the stimuli to be discriminated, or the difficulty of the task," and in the experiment (1961), merely decreasing the number of stimuli to be differentiated likewise decreased generalization among them and thus enhanced the learning rate. Similarly, Rieber (1961) hypothesized that the delay of reward in children is to facilitate the association of competing responses with the stimuli which elicit the conditioned response. Rieber (1961) concludes from the study that "Hence, it would be expected that interference with the conditioned response would be an increasing function of the similarity between the cues present during the delay period and those which elicit the conditioned responses." The conclusion of Noble and Alcock (1958) that "Whether reward or information is withheld seems to be of less consequence than what the subject does during the time interval between response and after effect." seems increasingly apt.

Saltzman (1951), in a study described earlier, attributed the poorer performance of the delay group to their interfering activity during the pre-reinforcement interval. The activity was rehearsal of the presented stimulus and since rehearsal was occurring prior to knowledge of the correctness of response, the incorrect response was reinforced as well as the correct one and interfered with acquisition. Brackbill, Bravos and Starr (1962) assume that the rehearsal activity is a major variable in learning. However, it is their (1962) contention that these covert responses are being strengthened, due to their being followed by reinforcement. Immediate reinforcement is not as facilitating since reinforcement precedes rehearsal.

The results from an investigation by Sturges and Crawford (1964) showed no differential effect in verbal learning due to the time of reinforcement and, in fact, one experiment revealed delay to be superior to immediate reinforcement. Sturges and Crawford conducted four experiments which compared the effectiveness of immediate and delayed reinforcement upon different types of learning material including nonsense syllables, factual material, and inductive generalizations. Reinforcement was presented in two forms: complete knowledge of results; and cues directing the subjects toward the correct answer.

In each experiment subjects were assigned to one of three groups: Immediate Reinforcement Group, in which knowledge of results was given immediately after answering each question; Delayed Reinforcement Groups in which knowledge of results was delayed for 24 hours; Control Group, in which no knowledge of results was given. Subjects were presented with learning material consisting of multiple-choice questions and their answers recorded immediately after seeing each question. They then received either immediate, delayed, or no reinforcement. All subjects were tested on the original learning material one week later. In each of the experiments the number of presentations of the material, the type of presentation of the material, the length of exposure of the material and the form of reinforcement was equated for all three groups.

The results of the four experiments indicated that in no case was immediate reinforcement superior to delayed reinforcement. When reinforcement was in the form of complete knowledge of results and when the type of material was either factual or inductive, the delayed reinforcement was more effective. Only when the material consisted of nonsense syllables or when reinforcement was given in the form of cues did immediate reinforcement equal that of delay in effectiveness.

The discrepancy between the findings of this study and those of the majority of previously reported studies in this area could be due to a number of different factors. Two plausible factors are the type of response and the specific function of reinforcement. The study dealt with verbal behavior in human subjects. Both the stimulus and the response were in the form of symbols, of which the subject has a large repertoire. Conditions were conducive for the subject to indulge in mediated activity, in the form of symbolic exploration of the material, during the interval between the response on record and reinforcement. Simple bar-pressing responses, motor skills on specialized apparatus, use of subjects from a lower species with a less complex nervous system, or subjects with scant symbolic repertoire would mitigate against any such mediating activity between the response and reinforcement, and against any such advantage caused by the delay of reinforcement. Thus, the results of preceding studies may favor immediacy because the experimental conditions were not conducive to mediated symbolic activity.

This implies that varying the probability of mediated symbolic activity would result in varying the effective temporal interval of reinforcement. Conditions should increase the efficacy of delayed reinforcement. Conditions tending to diminish symbolic activity should favor immediate reinforcement.

The above rationale which is consistent with the previous findings of the present authors suggests the need for further exploration of the relative effectiveness of immediate versus delayed reinforcement under varying academic learning conditions. Much typical classroom learning appears to be primarily concerned with the learning of concepts, i.e., classes of events, or of principles, i.e., relationships between concepts. Concepts and principles may be learned by either an inductive or deductive method. The present study was

in part an attempt to investigate the effects of simple intervals of reinforcement upon the learning of concepts and principles by both inductive and deductive techniques.

Furthermore, the rationale described above points to the conclusion that any conditions furthering relevant symbolic exploration of learning material will promote learning. Thus, interposing related stimulus material which although generally relevant in content does not contain the answer to the original question, should promote such symbolic activity and thus result in increased learning.

One limitation of the present authors' previous study was that learning was measured by recognition of the identical learning material. Probably a more useful measure and one analogous to the goals of classroom learning is a recall measure utilizing generalizations of the learned material to new instances.

Thus, the present series of studies was designed to explore the following variables and their interactions: a) temporal interval of reinforcement; b) inductive and deductive methods of learning concepts and principles; c) intervening stimulus material designed to promote symbolic activity but of a non-informative character. The measure of learning was generalization to new examples using a method of recall.

PROCEDURES

Design

A 2x2x3 Factorial design was utilized to explore the effects and interactions between the three variables of concern:

Variable A: The temporal interval between response and reinforcement.

Variable B: The presence of non-informative material designed to promote relevant symbolic activity during the pre-reinforcement interval.

Variable C: The method of learning--inductive or deductive.

Levels examined within each variable were:

1. For variable A, two levels: immediate, and delayed reinforcement.
2. For variable B, three levels: the presence of material which was non-informative, but designed to promote relevant symbolic material; the presence of material which was non-informative and not designed to promote relevant symbolic activity; and the absence of any such material.
3. For variable C, two levels: an inductive presentation, and a deductive presentation.

The design thus required twelve treatment groups, two temporal levels, two mode of inference levels, and three interpolated material levels. An outline of the design is portrayed in Table I.

DESIGN OUTLINE

Table I

A ₁						A ₂					
B ₁		B ₂		B ₃		B ₁		B ₂		B ₃	
C ₁	C ₂	C ₁	C ₂	C ₁	C ₂	C ₁	C ₂	C ₁	C ₂	C ₁	C ₂
A ₁ B ₁ C ₁						A ₂ B ₁ C ₁					
A ₁ B ₁ C ₂						A ₂ B ₁ C ₂					
A ₁ B ₂ C ₁						A ₂ B ₂ C ₁					
A ₁ B ₂ C ₂						A ₂ B ₂ C ₂					
A ₁ B ₃ C ₁						A ₂ B ₃ C ₁					
A ₁ B ₃ C ₂						A ₂ B ₃ C ₂					

Subjects

The subjects were two hundred and seventy-seven (277) lower division college students. All subjects were selected from one large (enrollment approximately 400) introductory psychology class. Students in this class had the option of participating in several experiments or writing a term paper. In this sense, all were volunteers. Students not participating in the experiment proper served with members of other preceding classes, as subjects in a series of pilot studies.

Employing a numerical code to identify subjects, a graduate assistant randomly assigned subjects to groups and groups to treatments.

Apparatus

An "800" Carousel slide projector was used to present the material. The learning material, including questions, answers, the similar and dissimilar material presented during the pre or post reinforcement intervals, etc., was photographed and made into 2" by 2" slides. Mimeographed question sheets were used in the test session.

The general experimental procedure was essentially the same for each group. The subjects were presented, by means of a slide projector, with the initial learning material in the form of multiple choice questions. The subjects made a response by marking the answer they thought correct and then received knowledge of results (KR) immediately or five minutes later. Material to elicit relevant and irrelevant activity was shown on the screen during the pre-reinforcement interval for delay groups or post-reinforcement interval for immediate KR groups. The subjects were tested twenty-four hours later.

The experiment was conducted in two sessions during the regular class period. Students were not informed of the retest. They were exposed to the

treatment conditions in small groups, seven to ten students. The procedure for the two sessions was as follows:

First Session. A booklet of six answer sheets was passed out to the subjects as they entered the room and took their seats. The experimenter told the group they were participating in a learning study concerned with the effectiveness of presenting materials in different ways and that their cooperation was essential to the outcome of the study. The following instructions were then given:

"You will be shown questions, on the screen, one at a time. While the question is exposed, think about the question and answers and when I give the work, you will have 15 seconds to fill in the correct answer. Do not answer the questions until I give the work, but you must fill in an answer. After you have filled in the answer, you will be instructed to tear off the sheet and turn it over. Attempt to learn the correct answer."

The subjects were then told to remain seated and refrain from talking during the experimental session.

All subjects were presented a multiple choice question. For the inductive groups the stem of the question consisted of an example of the principle. The alternatives consisted of the correct principle exemplified in the stem, and three incorrect principles. For the deductive groups the stem consisted of a statement of the principles; the alternatives were three non-exemplars and one correct example. After one minute, each group was instructed to mark their selected answer, tear off the answer sheet and turn it over.

1. The delayed reinforcement groups given irrelevant material during the interval were then presented with fifteen German prepositions and their English equivalents on the screen with the instructions, "Attempt to memorize these German words."
2. The delayed reinforcement groups given relevant material during the interval were presented with material similar to the concept to be

learned and told "Here is some information relevant to the question, attempt to learn it."

3. The delayed reinforcement groups given no material during the interval were presented a blank screen for five minutes and given no instructions.

This sequence was replicated six times; each presentation consisting of a different principle to be learned.

The procedures for the immediate reinforcement groups were essentially the same; however, the supporting material was presented during the post-reinforcement rather than the pre-reinforcement interval.

The temporal sequence of question (Q) response (R) and knowledge of results (KR) was as follows:

1. For the delayed feedback groups.

1' 15"	5'	30"	10"	1' 15"	
Q ₁	R ₁		KR ₁	Q ₂	R ₂

2. For the immediate feedback groups.

1' 15"	30"	5'	10"	1' 15"	
Q ₁	R ₁	KR ₁		Q ₂	R ₂

During the five-minute interval either the material designed to stimulate relevant symbolic activity, the material not so designed, or a blank screen was presented.

At the end of the session, each group was given instructions as follows:

"Thank you very much for your cooperation. It is very important that you do not discuss this experiment with anybody. We will be glad to discuss this experiment with you anytime after Monday. Thank you again for your cooperation, you may now leave."

Second Session. The subjects were retested twenty-four hours later, in their classes. The retest, consisting of two parts, was:

1. A test sheet with the general title of the six principles and instructions for the subjects to elaborate on or describe the principle more specifically.
2. A test sheet with six multiple choice questions; each question consisted of the title of a general principle and four possible examples of the principle.

Ten minutes was allowed for the completion of each part.

Materials

A review of standard published sources failed to disclose suitable learning material for this study. Consequently, materials were developed. Considerations guiding the development of the material to be learned were:

1. Subjects prior to the treatment would be unable to identify principles, or examples at greater than chance levels.
2. Subjects could display some evidence of learning after relatively brief treatments. However, learning would not occur to such a degree that perfect performance would mask sources of variance.
3. Principles were similar to those found in lower division college course materials.
4. A number of exemplars and non-exemplars of each principle could be identified.

Pilot studies were devoted to such development. During Fall and Winter Quarters, over 400 subjects were involved in a series of pilot studies directed toward the development of appropriate materials and procedures. Students enrolled in the same course designation as that from which the treatment subjects were selected were employed in these pilot efforts.

The principles as selected are contained in Appendix A.

Supporting material, for Variable B as described in the design of the experiment, was developed for each principle so that the supporting material referred to the same content area and instructed the subjects to think about relevant categories within that area, but did not offer any information from which legitimate inferences identifying principles or examples could be made. Relevant material consisted of brief paragraphs of two to four sentences concerning the content area from which the principles were selected. Only concepts consistent with those of the principle in question were included. Pilot studies indicated that subjects did not, either logically or illogically, leap to correct inferences solely from the supporting material. The development of material designed to engage the student in symbolic activity, but not principle relevant, led to the use of German words. Fifteen prepositions were finally selected. Subjects were instructed to learn the German word and its English equivalent. Pilot Ss reported sustained involvement in this task and were unable to recall any process or content that appeared related to the principles to be learned.

The relevant supporting material is contained in Appendix B; the irrelevant in Appendix C.

ANALYSIS OF DATA AND FINDINGS

The study was designed as a $2 \times 2 \times 3$ factorial design. Data were analyzed by a factorial analysis of variance using the hypergeometric correction due to somewhat unequal n's in several sub groups.

Two measures were taken: An essay recall of principles and a multiple choice matching of principle with a new example. The subjects' performance in the six essay-type questions were rated by judges according to specific

predetermined criteria (Appendix D) and scored on a zero, one-half, one, and two point scale. Three graduate student raters were instructed in the application of the criteria and independently performed the ratings. Interrater reliability exceeded .90.

An analysis of variance of the rated scores was performed to compare main effects and interactions. No significant effects were revealed in any of the comparisons. Thus, with respect to recall of principles none of the variables simply or in combination displayed any significant relationship to the outcome.

The second measure, the matching of principle to new example was similarly analyzed in a 2x2x3 factorial design. Factors and levels are as follows: Factor A signifies the mode of presentation: A_1 = inductive; A_2 = deductive. Factor B signifies the kind of material presented during the delay interval for delayed group and after feedback for the immediate group. The three levels represented within factor B are: B_1 = relevant material; B_2 = no material; B_3 = German words. Factor C signifies the temporal measure of feedback: C_1 = delayed; C_2 = immediate. Results on this analysis of variance are summarized in Table II.

SUMMARY OF ANALYSIS OF VARIANCE

Table II

Source	SS	df	MS	F
A	28.55	1	28.55	2.17
B	106.85	2	53.43	4.07*
C	2.21	1	2.21	----
AxC	122.62	1	122.62	9.34**
BxC	50.79	2	25.39	1.93
AxB	2.73	2	1.36	----
AxBxC	41.13	2	20.56	1.56
Treatments	354.88	11		
Within	3477.92	265	13.12	* .05 ** .01
Total	3832.80	276		

Only one main effect was significant, B, the kind of interpolated material presented. Orthogonal comparisons between levels within factor B show that the effect was due to the divergence of level B_1 from the other two levels. B_1 , the similar material, showed significantly lower retention than either the irrelevant German words B_2 or the absence of any such material. There were no differences between groups presented German words and those presented a blank screen during such intervals. The orthogonal comparison within B are summarized in Table III.

SUMMARY OF ORTHOGONAL COMPARISONS
WITHIN FACTOR B: SUPPORTING MATERIAL

Table III

Source	SS	df	MS	F
B_1 vs $B_2 + B_3$	91.4	1	91.4	6.97**
B_1 vs B_2	17.74	1	17.74	1.35
	109.14	2		
Within	3477.92	265	13.12	

One interaction was significant; that between mode of presentation and temporal feedback. This A x C interaction shown in Table II reveals that:

1. Within the inductive treatment the immediate feedback groups perform significantly better than the delayed feedback groups.
2. Within the deductive treatment, the delayed feedback groups perform better than the immediate feedback groups.

Briefly, immediate KR appears superior for inductive learning, delayed KR appears superior for deductive learning.

SUMMARY OF ORTHOGONAL COMPARISONS
WITHIN INTERACTION A x C: TEMPORAL INTERVAL AND METHOD OF LEARNING

Table IV

Source	ss	df	MS	F
A_1C_2 vs $A_1C_1 + A_2C_1 + A_2B_2$	113.3	1	113.3	8.64**
A_2C_1 vs $A_1C_1 + A_2C_2$	31.76	1	31.76	2.42
A_2C_2 vs A_1C_1	11.29	1	11.29	
	166.35 (122.62)	3		
Within	3477.92	265	13.12	

Table IV indicates orthogonal comparisons within this interaction. The significant component compares the inductive-delay group against the weighted sum of the inductive-immediate group, the deductive-delay group, and the deductive-immediate group. All other interactions and components display no significant differences.

CONCLUSIONS AND IMPLICATIONS

Four hypotheses were stated earlier in this report. They were:

1. Delayed feedback will result in superior verbal learning.
2. The presence of non-informative symbolic supporting will result in superior verbal learning as compared to the absence of such material.
3. The interaction between temporal interval of feedback and supporting material will be significant. Such significance will result from the positive learning increment due to both delayed feedback and induced symbolic activity.
4. The hypotheses indicated above (1, 2, and 3) will be supported by both inductive and deductive methods of presentation.

As stated, none of the hypotheses were supported.

The major objective of the study was to compare the effect of immediate -- delayed KR using instructional material typical of college courses. No overall differential effects were found. This however, masks the significant and provocative interaction between delay of KR and mode of inference. That delayed KR would result in superior learning for the deductive treatment groups, while immediate KR would result in more learning for the deductive treatment groups was not expected. A first-order conclusion seems warranted. The universal superiority of immediate reinforcement did not appear. Over a major subset

of treatment conditions, six groups, there was not only no superiority but a significant inferiority in learning outcomes associated with immediate KR. Of course, the converse is also true, a generalization as to the overall superiority of delayed KR with academic material cannot be supported.

The peculiar interaction between mode of inference and timing of reinforcement suggests the flow of somewhat different processes occurring between induction vs deduction so that the timing of KR results in a differential effect. One possibility is that the sort of principles used in these experiments were readily retained symbolically over the five-minute delay interval. Experimental conditions apparently were conducive to frequent rehearsal of the principle. Although a search for the correct examples might have been unsuccessful, the continuous rehearsal of principle rendered the subsequent KR more effective. In the case of the inductive treatment groups, only the example was available for rehearsal before KR. Thus, no enhancing effect was possible. The inductive groups, performing symbolic manipulations from the focus of the example had little basis to conduct such reiterated processing. Principles are more useful tools to carry than examples.

A puzzling result was not only the lack of positive effect from the materials designed for relevant symbolic support but their apparent interfering effect. Learners with such intended support learned less than the other groups.

The lack of any positive increment could be due to the characteristics of the learning setting. It was test-like. The college subjects are notoriously test-motivated and over the brief five-minute period no symbolic support was needed. However, the apparent negative effect remains difficult to explain. Observations of the subjects indicated that subjects in both the relevant material and the no material groups began looking around the room, scribbling on their

answer sheets, twisting and squirming, etc. The material may have failed, despite supporting evidence from pilot subjects, to maintain the desired covert processes over the interval. If so, the material itself may here become a discriminative stimuli for behavior contradictory to the desired learning.

The major educational implications of the study are twofold:

1. The usual assumption of the efficiency of immediate reinforcement is not valid with respect to academic instruction.
2. The apparent superiority of delayed KR with deductive learning and immediate KR with inductive learning may be utilized across a wide range of instructional settings.

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APPENDIX A

**Reinforcement in the Form of Knowledge of
Results for Each of the Six Responses**

Reinforcement in the Form of Knowledge of Results

Reinforcement 1

The intensity of sensation is equal to the intensity of the physical stimulus squared (Multiplied by itself).

Reinforcement 2

Adolescents have trouble relating to father figures.

Reinforcement 3

When two mixable liquids which do not react chemically are placed in the same vessel, a slow mixing process occurs from the molecular motion and the liquid becomes uniform throughout.

Reinforcement 4

An argument from an accepted rule or principle to a special case, when the rule is not applicable to the special case.

Reinforcement 5

Learning a single concept is facilitated by all positive instances, but this interferes with later learning of more complex concepts.

Reinforcement 6

If you do something in a given situation, the next time you are in that situation, you will tend to do the same thing.

Relevant Material

Material Relevant to Stimulus 1

These four problems, detection, recognition, discrimination, and scaling, constitute the core of a segment of experimental psychology called psychophysics. The name psychophysics derives from the classical question about the relation between the physical environment and the mind. Today, modern psychophysicists are not professionally concerned with this philosophical issue of the mind-body relation, but rather with the constraints that are placed upon the behavior of a person in his judgments, actions, and so on, by the sea of physical energies that surround him.

Material Relevant to Stimulus 2

Childhood continues up to the time when the child can get on fairly well with his peers; the juvenile era begins when playmates are badly needed and are, in most ways, preferred to adults. The "eruption, due to maturation, of a need for an intimate relation with another person of comparable status" marks the beginning of pre-adolescence, a relatively brief period which ends with puberty. Adolescence is marked by a shift of interest from a person of one's own sex to one of the opposite sex, and by the patterning of adult sexual activity. At adulthood one is able, for the first time, to establish a love relationship in which the other person is almost as important as oneself.

Material Relevant to Stimulus 3

The first step in applying the scientific method is to obtain some facts, by observation and experiment. The next step is to classify and correlate the facts by general statements. If a general statement is simple in form it may be called a law of nature. If it is more complex it is called a theory. Both laws of nature and theories are called principles.

Material Relevant to Stimulus 4

In logic an argument is a group of two or more statements, one of which is affirmed on the basis of the other or others. The statement which is affirmed is called the conclusion of the argument. The statement or statements which supply the reason or reasons for affirming the conclusions are called the premises of the argument.

Material Relevant to Stimulus 5

Concepts are condensations of past experience. They bring together in a single idea, so to speak, what has been learned about properties of many different things. Take, for example, the concept tree. This concept is foreign to certain Australian tribes. The native speaks of particular objects, like the jarrah, the mulga, and the gum, but he has no word to represent what is common to them.

Material Relevant to Stimulus 6

An example of laboratory learning, on classical conditioning, is the conditioning of the eyeblink reflex in humans. If a person who is watching a dim light sees the light grow somewhat brighter, he ordinarily does not blink his eyes in response to this stimulus. If, however, he is hit in the eye by a vigorous puff of air, he does blink. The conditioning procedure consists in pairing these two stimuli, with the brightening of the light coming a fraction of a second before the puff of air. Each time this sequence occurs, the subject blinks in response to the air puff. Presently, however, he begins to blink as soon as the light changes, before the puff comes. Since the changing light now produces a blinking response which it formerly did not produce, learning has taken place. In this setup the puff, which already produced blinking, is called the unconditioned stimulus, and blinking to the puff is the unconditioned response. The increase in brightness of the light is called the conditioned stimulus, and the learned response of blinking to it is the conditioned response. The whole learning sequence is known as conditioning.

APPENDIX C

**Material Irrelevant to the Principle to be
Learned for Eliciting Irrelevant
Pre-Reinforcement Activity**

Irrelevant Material

German	English
1. lachen	1. to laugh
2. reden	2. to talk
3. erlau'ben	3. allow
4. leben	4. to praise
5. schicken	5. send
6. desto	6. the
7. bei	7. with
8. errei'chen	8. reach
9. an'-zichen	9. put on
10. wecken	10. wake up
11. begeg'nen	11. meet
12. drucken	12. press
13. fressen	13. devour
14. Zwischen	14. between
15. suchen	15. seek

APPENDIX D

Criterion for Evaluating the Essay

Questions of Test Part I

Criterion for Evaluating Test Part I

Score	Criteria
2	Principle is correctly stated or substantially correct (allow some incompleteness or vagueness).
1	Approximate principle, but relationship between variables not correct, or some variables left out.
1/2	Correct example only.
0	Wrong example, wrong principle, failure to answer.

Note: combination of answers do not get additional credit. Thus, approximate principle and a correct example receive 1 point only.

SUMMARY

Title: THE EFFECT OF TEMPORAL INTERVALS OF REINFORCEMENT UPON
DEDUCTIVE AND INDUCTIVE GENERALIZATIONS

Investigator: Jack J. Crawford

Institution: Central Washington State College, Ellensburg, Washington

Project Number: S-271

Duration: June 1, 1965 through August 31, 1966

BACKGROUND

The view that learning varies inversely with the amount of time intervening between a response and reinforcement is incorporated in several prominent theoretical approaches to learning (Hull, 1952; Spence, 1956; Miller, 1950; Skinner, 1938, 1957). Furthermore, this notion of the superiority of immediate reinforcement has been included in almost all attempts to apply principles of learning to education practices.

However, evidence for the superiority of immediate reinforcement for cognitive learning is inconclusive. It is questionable whether generalities based primarily upon motor responses of other experiences are applicable to the learning of typical academic material.

This study explored the effect of delayed feedback upon principle learning.

OBJECTIVES

1. To compare the effect of immediate versus delayed feedback.
2. To explore the interaction of immediate and delayed feedback upon deductive and inductive modes of learning.
3. To explore the effect of the presence or absence of material supporting relevant symbolic activity as it interacts with the above verbals.

PROCEDURE

A 2x2x3 factorial design was utilized to explore the effects and interactions between the three variables of concern:

Variable A: The temporal interval between response and reinforcement.

Variable B: The presence of non-informative material designed to promote relevant symbolic activity during the pre-reinforcement interval.

Variable C: The method of learning--inductive or deductive.

The subjects were two hundred and seventy-seven (277) lower division college students.

The learning materials used in the experiment consisted of six verbally expressed principles and exemplars and non-exemplars of each principle such as:

1. Subjects prior to the treatment would be unable to identify principles or examples at greater than chance levels.
2. Subjects could display some evidence of learning after relatively brief treatments.
3. Principles were similar to those found in lower division college course materials.
4. A number of exemplars and non-exemplars of each principle could be identified.

Two by two by three factor analysis of variance, using the hypergeometric correction, is used to analyze the data. Data thus analyzed consisted of correct matching of principles with new exemplars.

RESULTS AND CONCLUSIONS

Only one main effect was significant: The kind of interpolated material presented. Material designed to promote relevant symbolic activity resulted in less learning than either material designed to promote non-relevant symbolic activity or no material. One interaction was significant, that between mode of instruction and temporal interval of feedback. Whether immediate or delayed feedback was more advisable, depended on whether the mode of learning was inductive or deductive. Deductive learning was best supported by delayed knowledge of results; inductive learning by immediate knowledge of results.

BIBLIOGRAPHY

There are 158 references listed in the final report.

PUBLICATIONS

None.